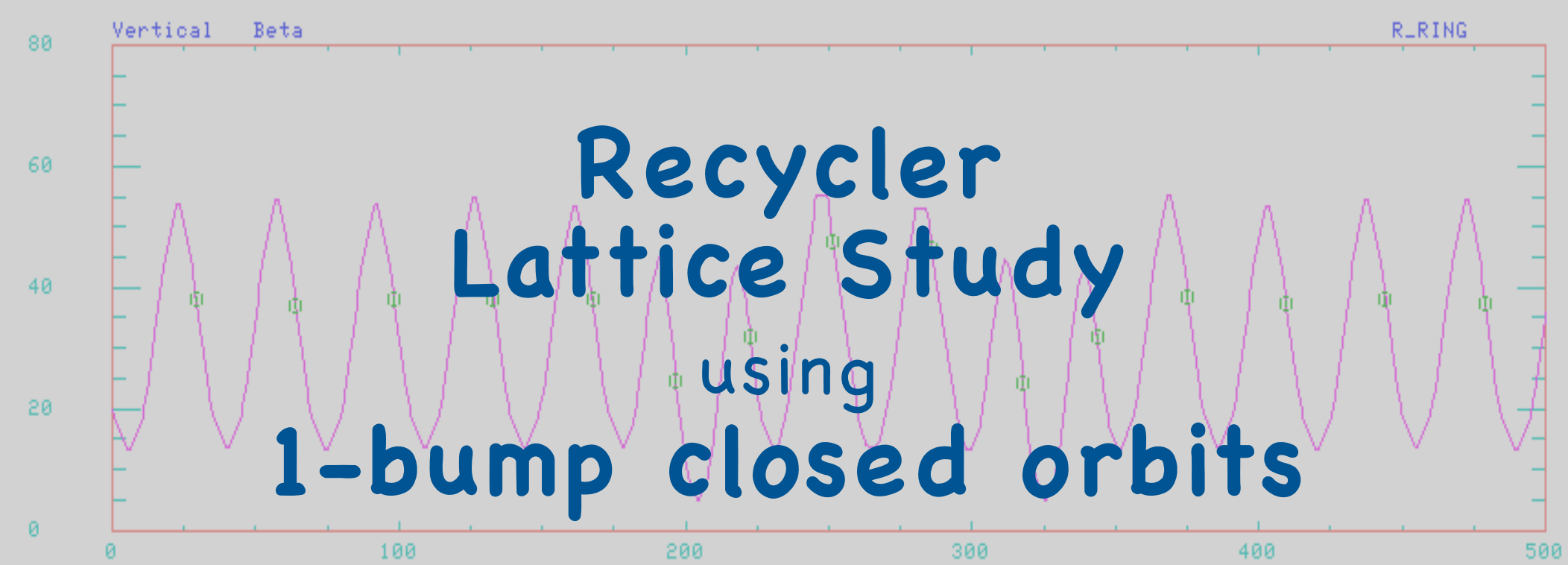
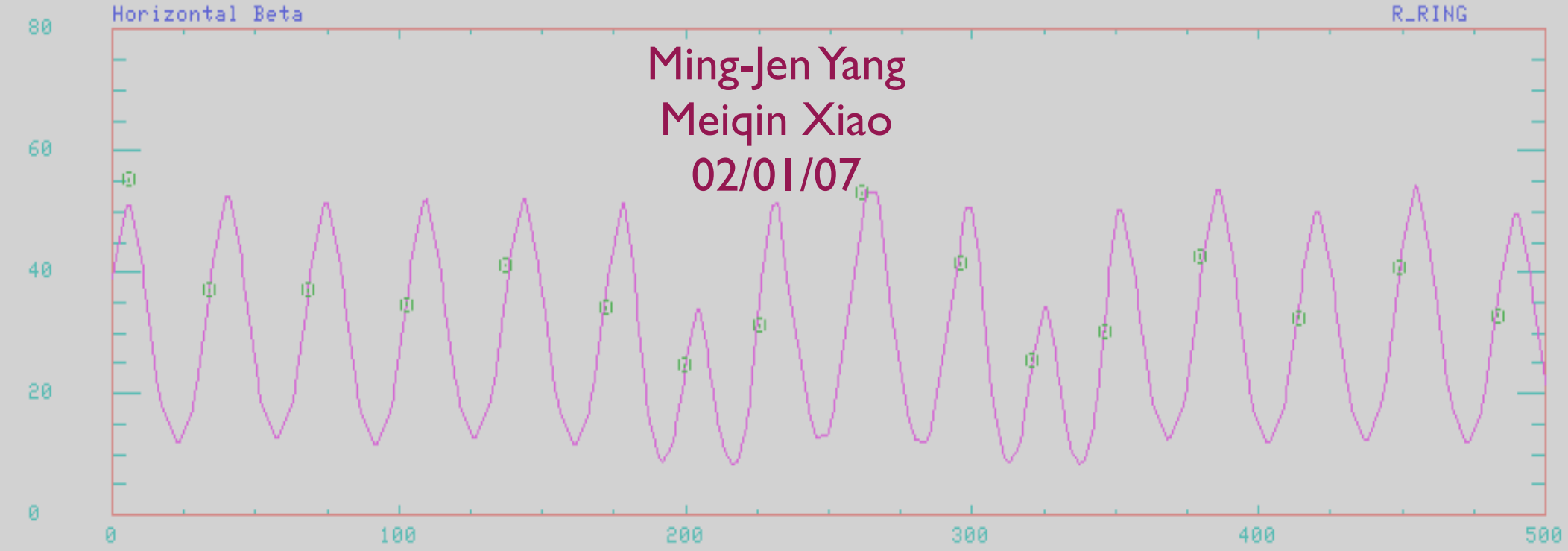


Recycler Lattice Study using 1-bump closed orbits

Ming-Jen Yang
Meiqin Xiao
02/01/07



Data

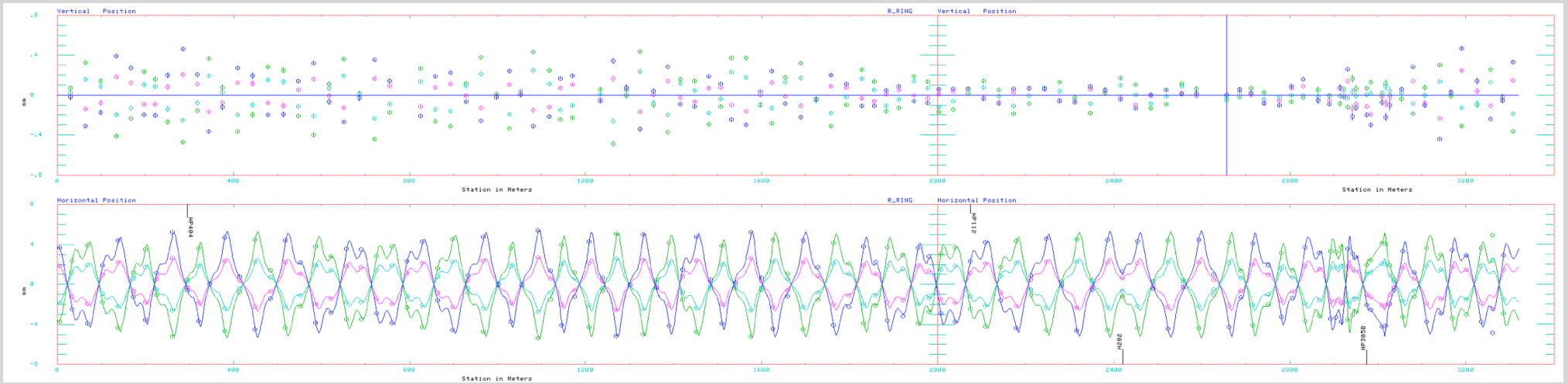
- Proton data
  - Circulating beam.
- 1-bump orbit
  - Horizontal plane
    - H202, H204.
  - Vertical plane
    - V203, V205.
- Trombone
  - With trombone at nominal setting.
  - Set trombone to zero.

Analysis objectives

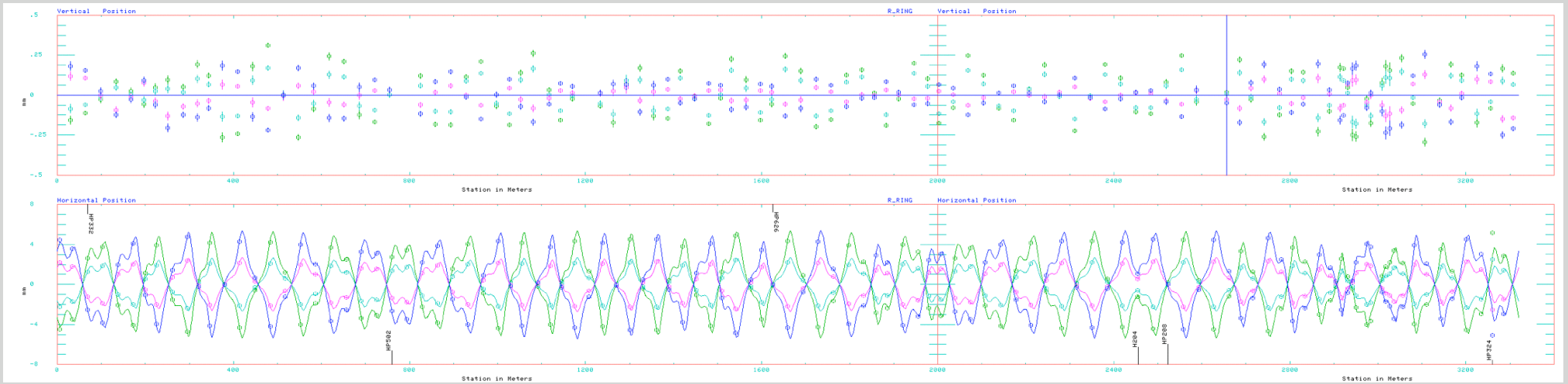
- Coupling
  - On plane data
    - Compare with expected linear response orbit.
  - Cross plane data
    - Use MICADO to find coupling source locations.
    - Result were incorporated in the R90 calculation
- Lattice function with & without trombone
  - Use two corrector at ~90 degree algorithm
    - Phase advance.
    - Beta function.
  - Apply BPM calibration
    - $\frac{\Delta\beta}{\beta} \propto (\Delta gain)^2$
    - Gain derived from TBT data of December 2004.

Horizontal 1-bump orbits

H202 at -2, -1, +1 & +2 amps from nominal

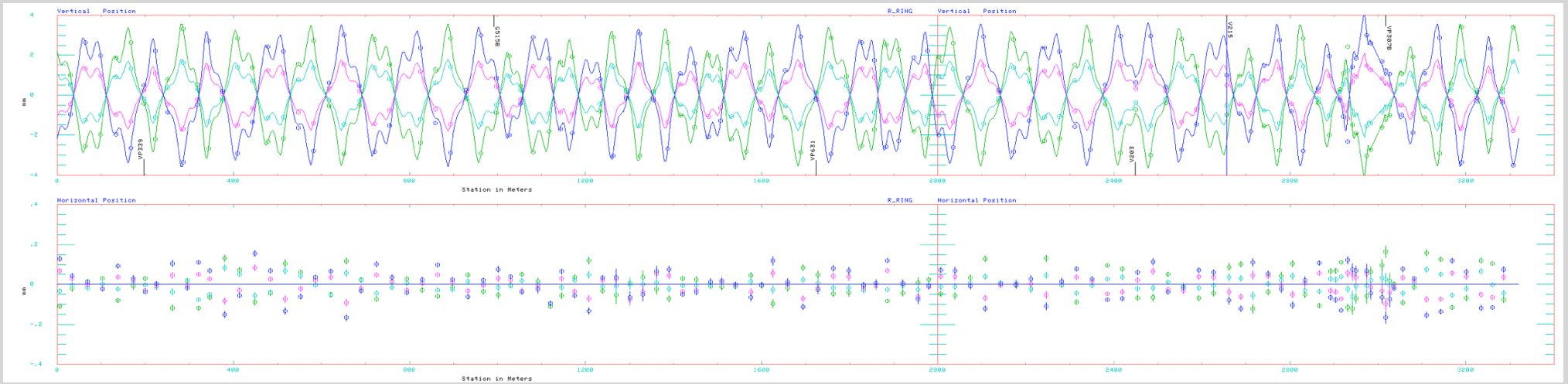


H204 at -2, -1, +1 & +2 amps from nominal

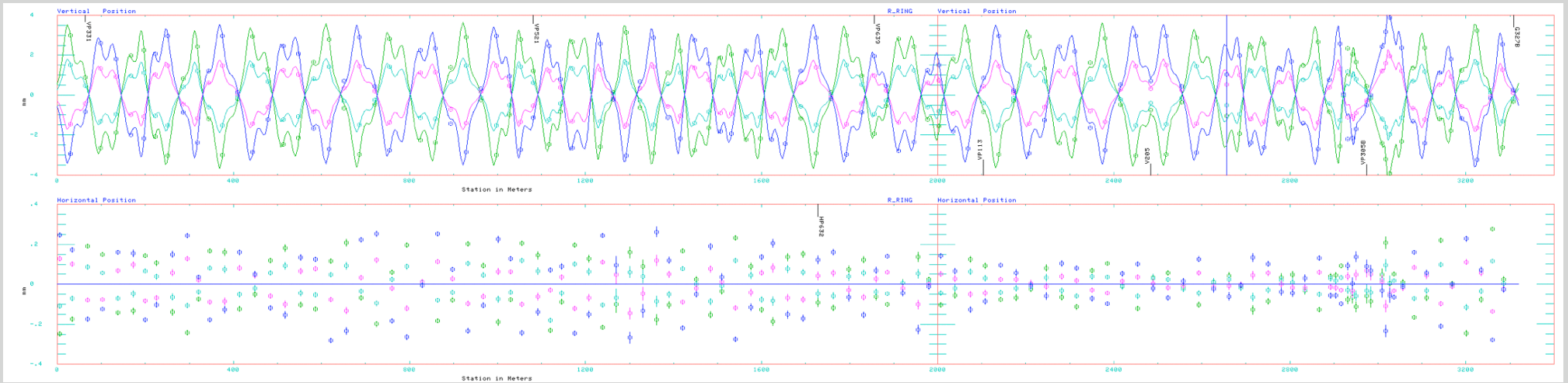


Vertical 1-bump orbits

V203 at -2, -1, +1 & +2 amps from nominal

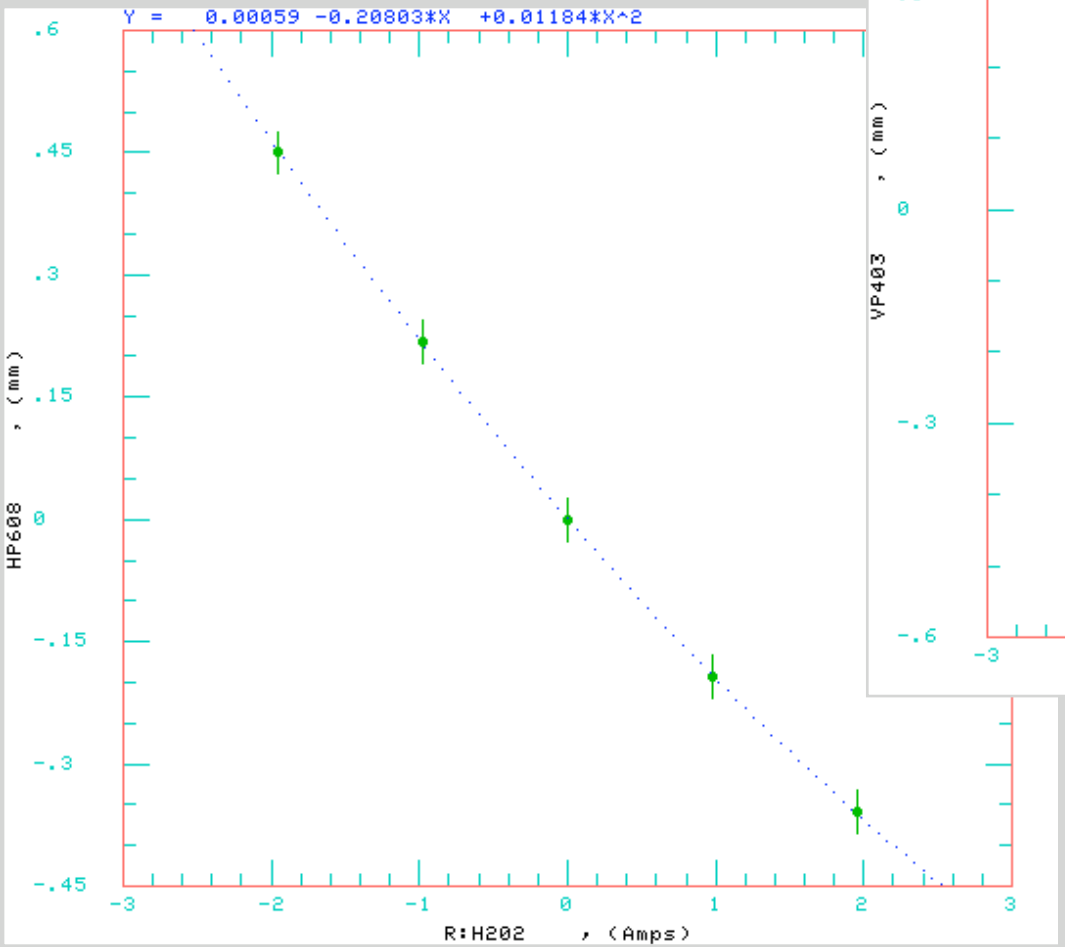


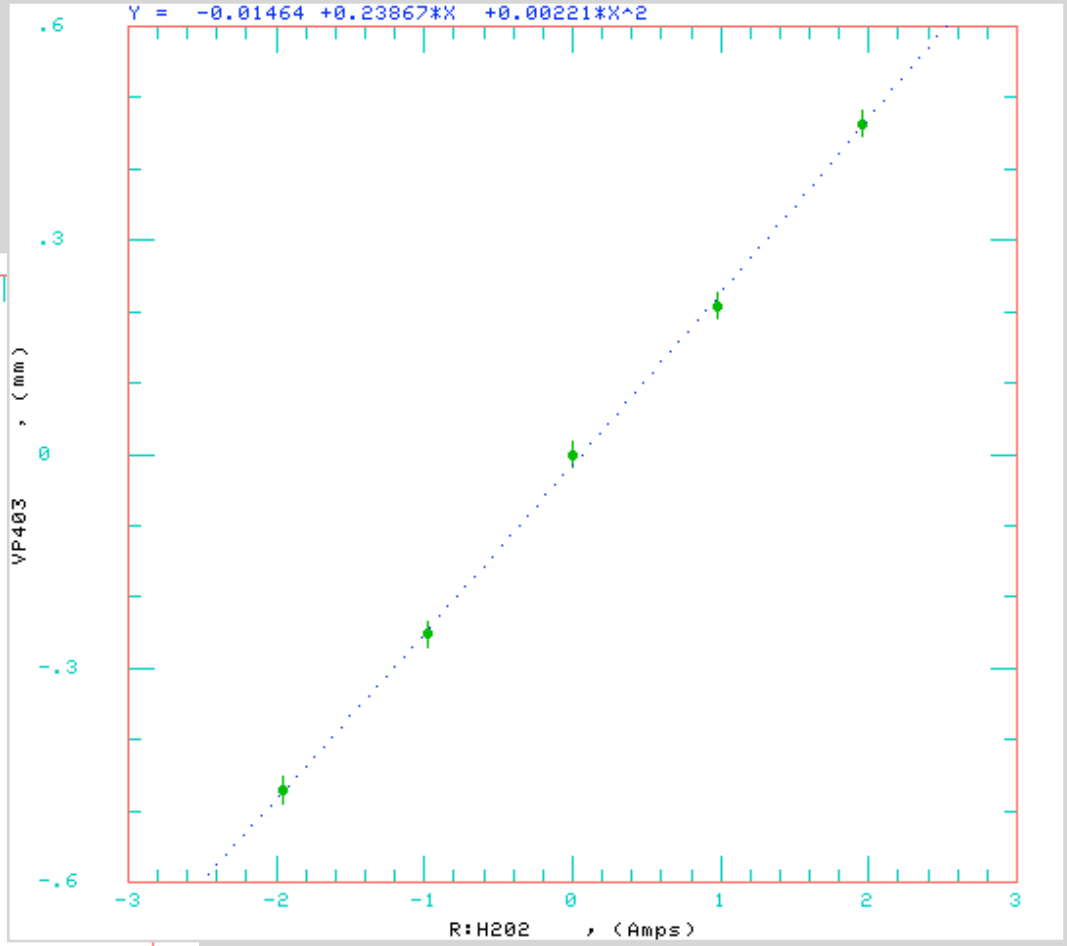
V205 at -2, -1, +1 & +2 amps from nominal



Position response examples, H202

On plane, HP608

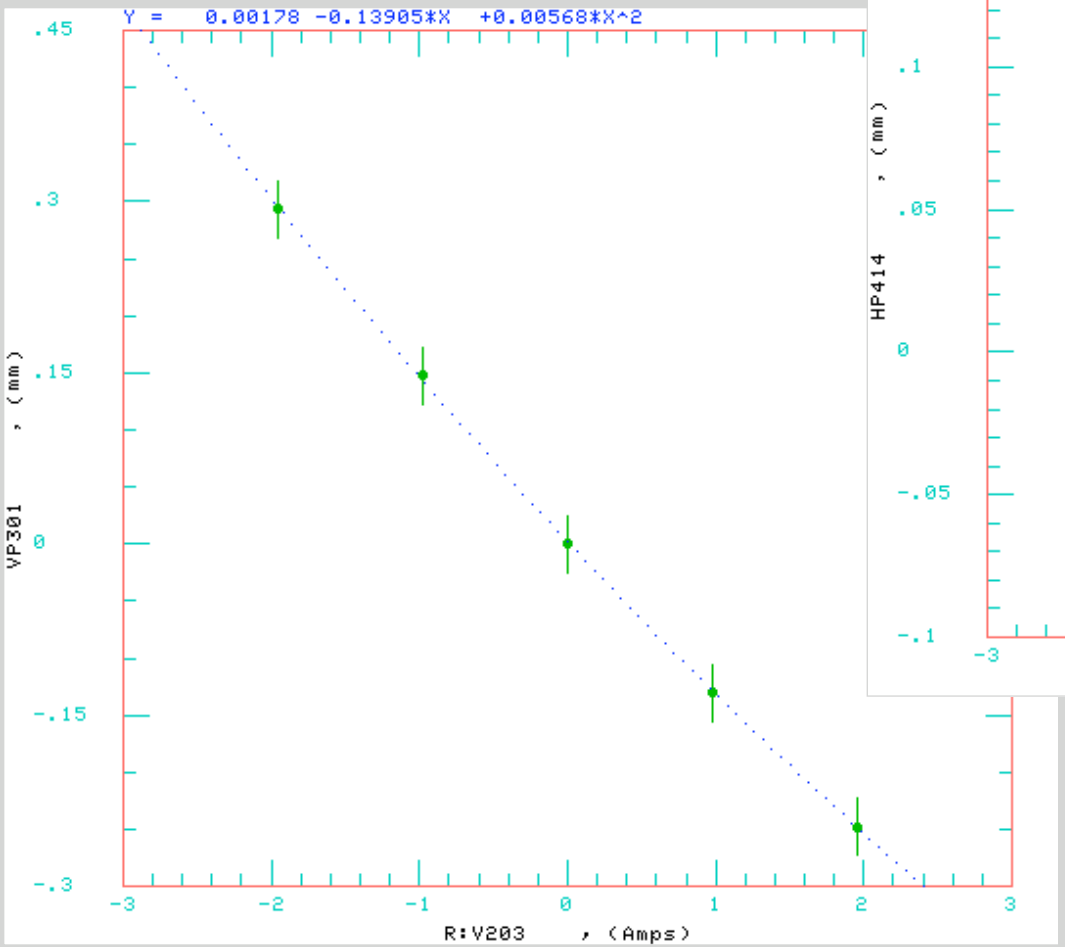


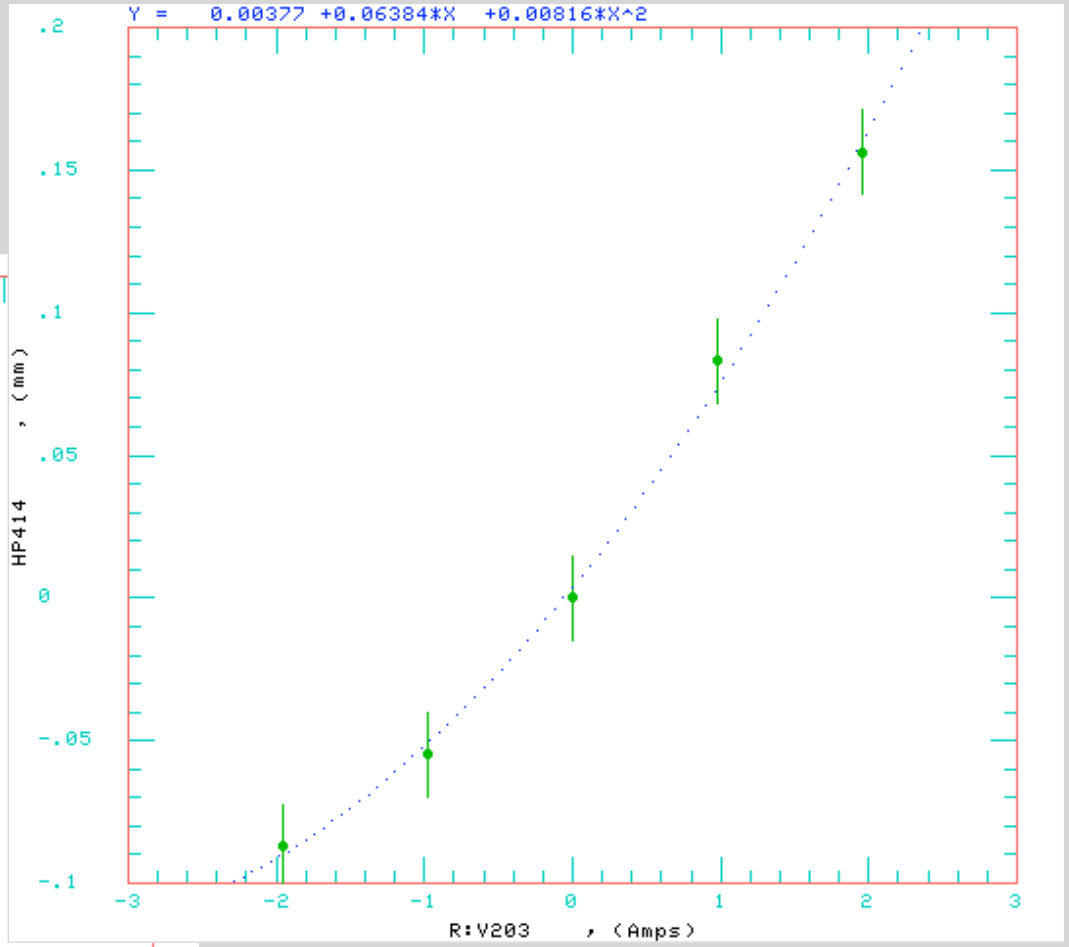


cross plane, VP403

Position response examples, V203

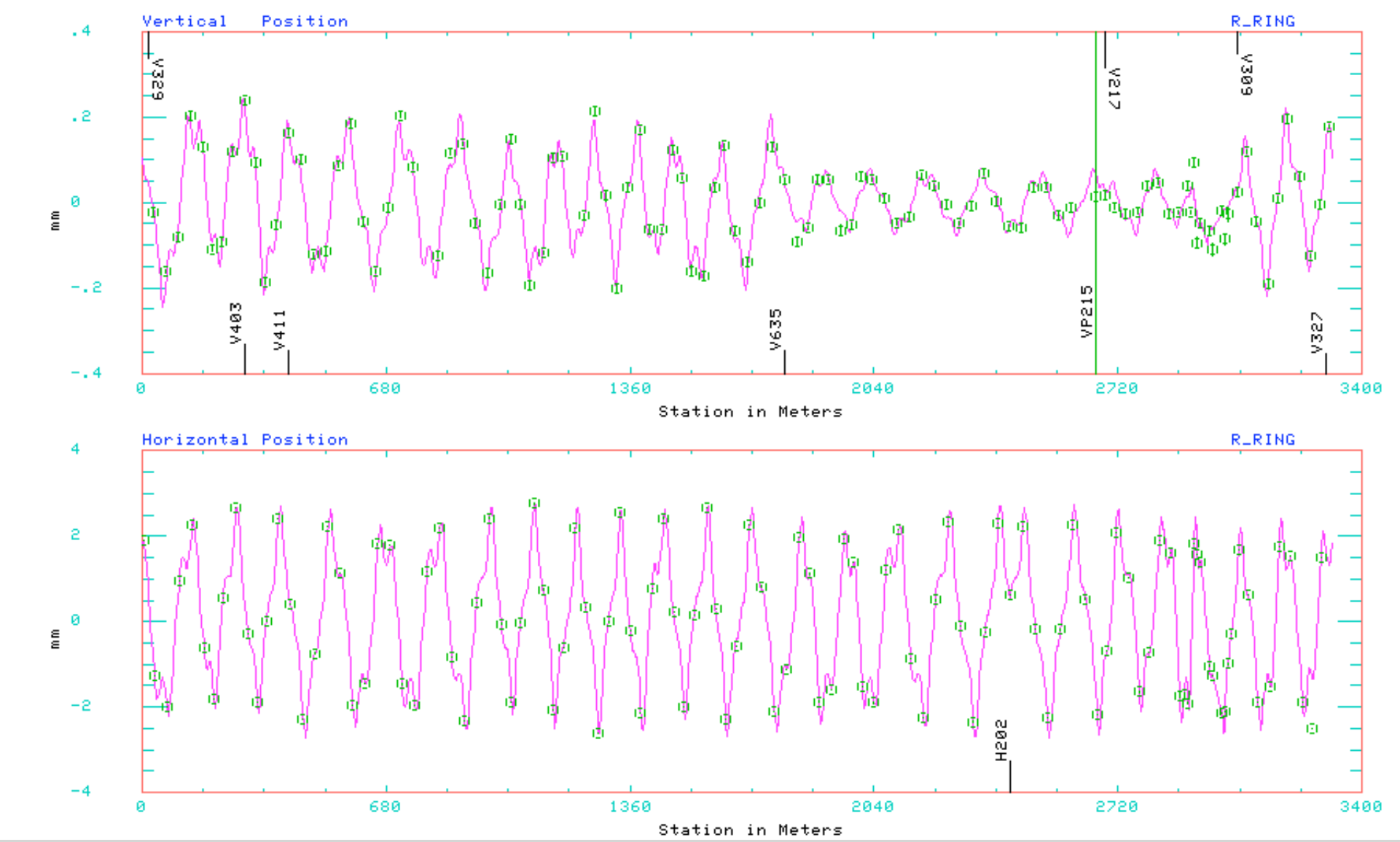
On plane, VP301



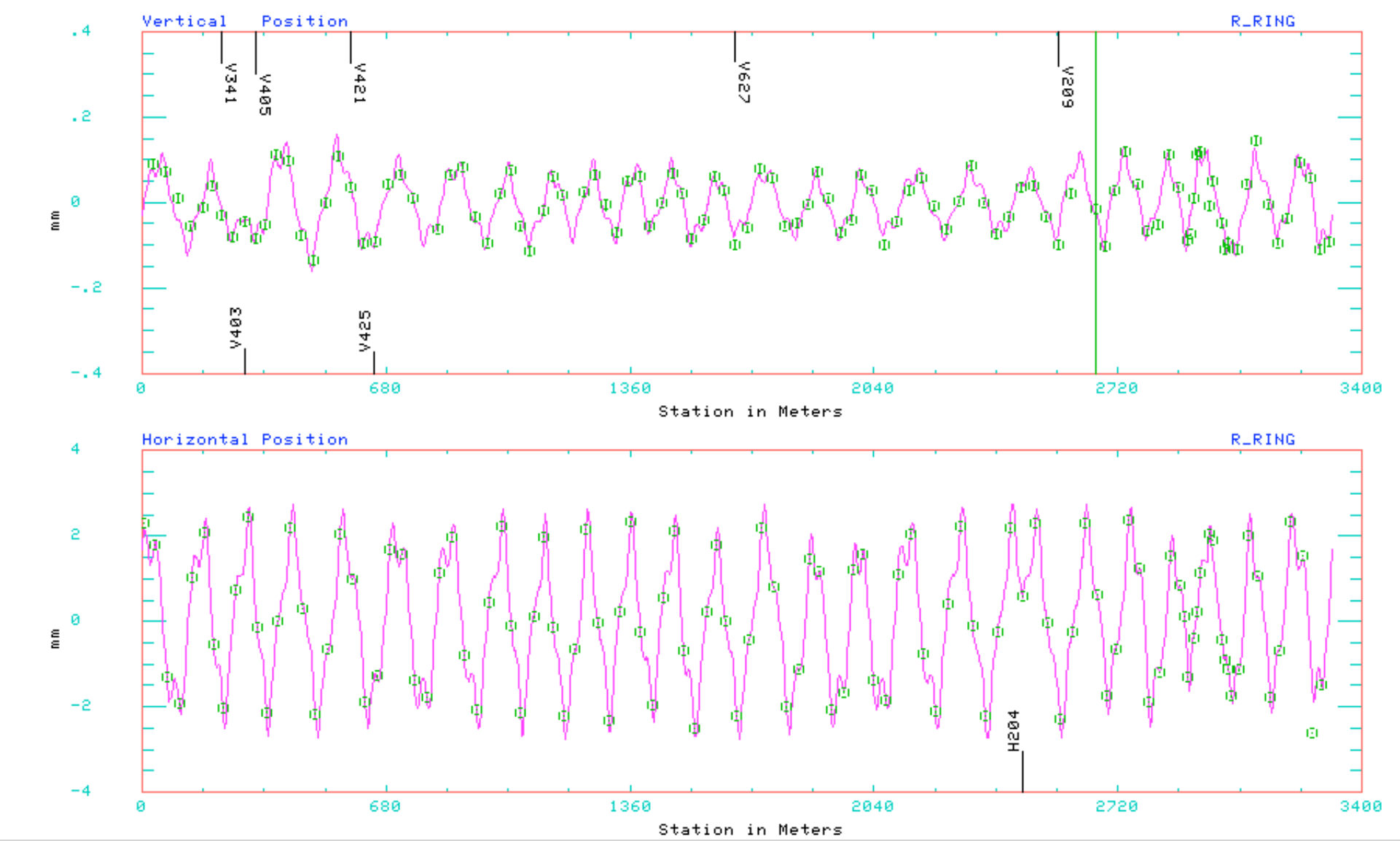


cross plane, HP414

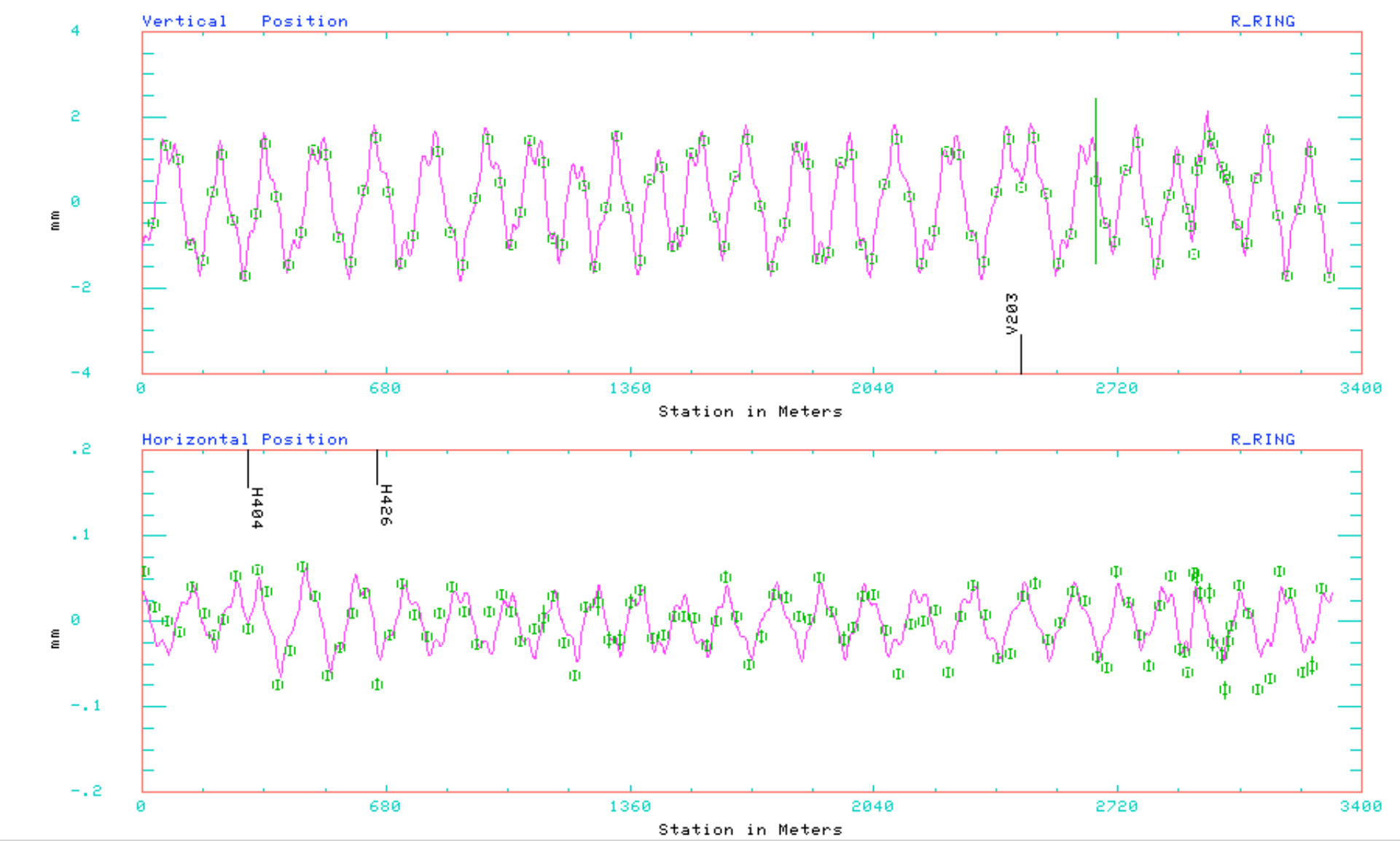
H202 1st order response, (mm/Amp)



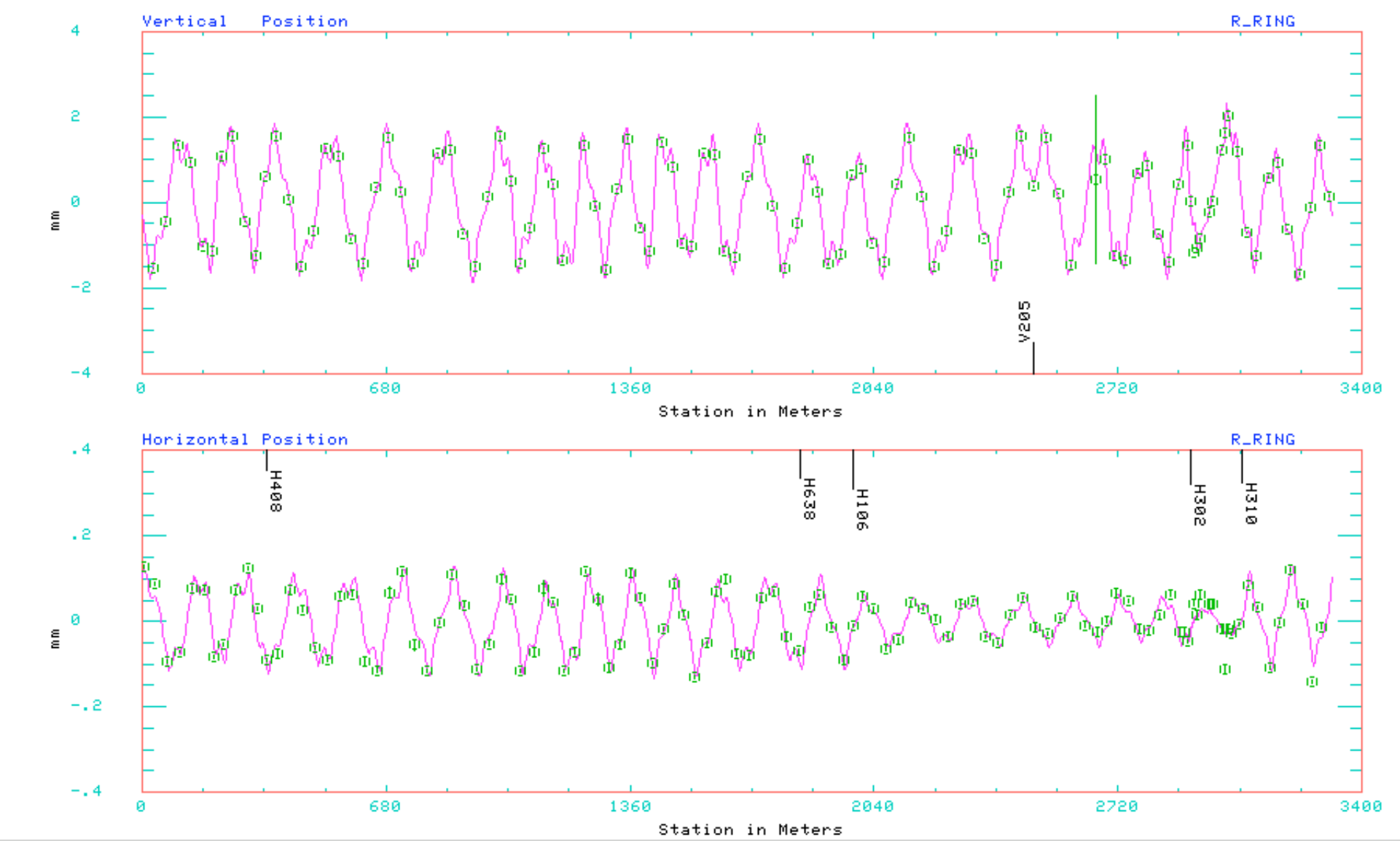
H204 1st order response, (mm/Amp)



V203 1st order response, (mm/Amp)



V205 1st order response, (mm/Amp)



MICADO fit to cross-plane orbits

H202 vert orbit fit

Fit result

H202 1st order

	Old	Delta	New	
R:V217	-0.594	-0.049	-0.643	A
R:V309	0.918	-0.042	0.876	A
R:V327	1.483	0.031	1.514	A
R:V329	1.345	0.021	1.366	A
R:V403	1.873	-0.038	1.835	A
R:V411	-0.048	0.025	-0.023	A
R:V635	1.337	-0.040	1.297	A

<Return>

H204 vert orbit fit

Fit result

H204 1st order

	Old	Delta	New	
R:V209	-0.386	-0.024	-0.410	A
R:V341	0.361	-0.010	0.352	A
R:V403	1.873	0.047	1.920	A
R:V405	-0.316	0.046	-0.270	A
R:V421	-1.072	-0.007	-1.079	A
R:V425	-1.983	0.014	-1.970	A
R:V627	-0.605	-0.013	-0.618	A

<Return>

V203 horz orbit fit

Fit result

V203 1st order

	Old	Delta	New	
R:H404	0.926	-0.020	0.907	A
R:H426	0.120	-0.006	0.115	A

<Return>

V205 horz orbit fit

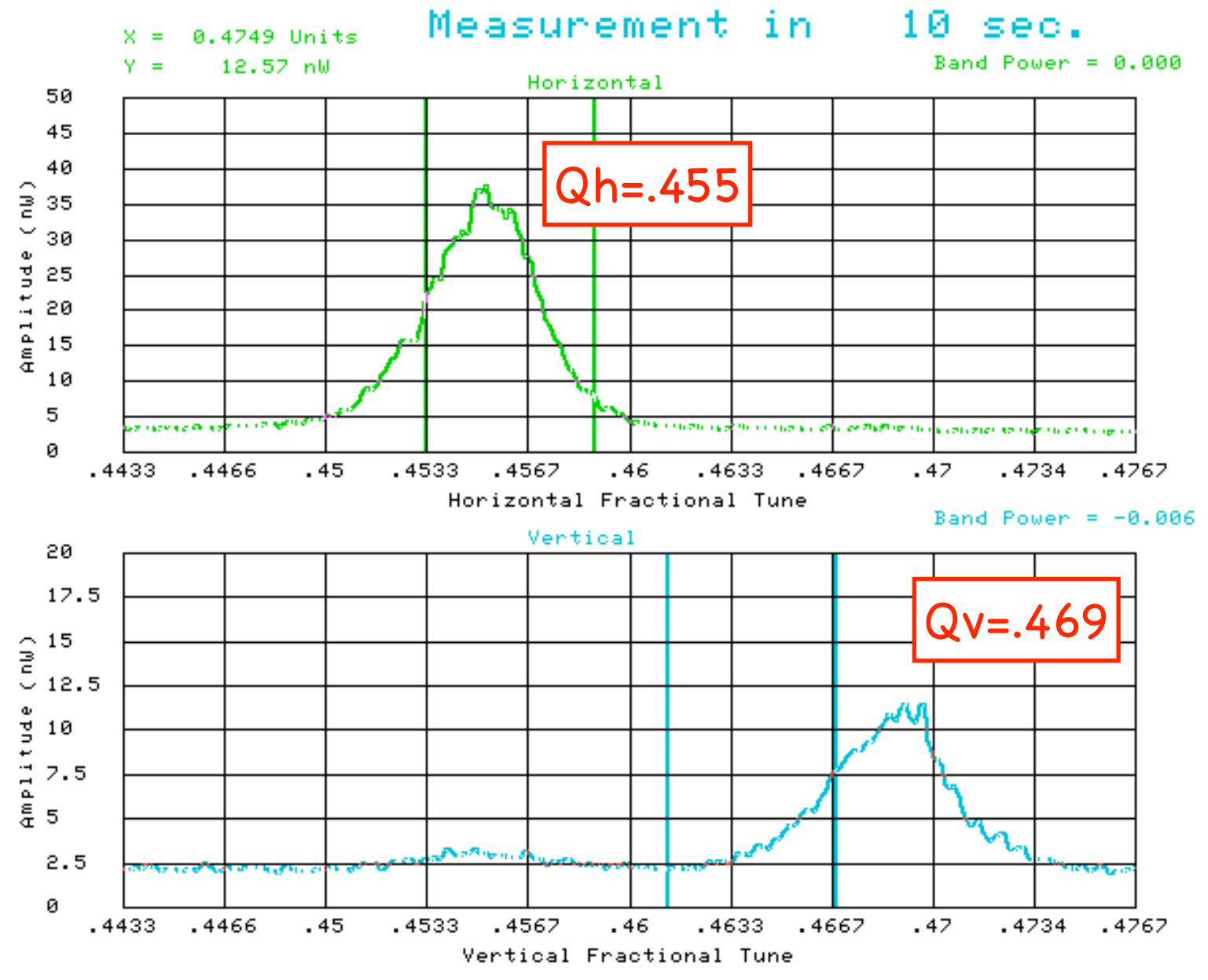
Fit result

V205 1st order

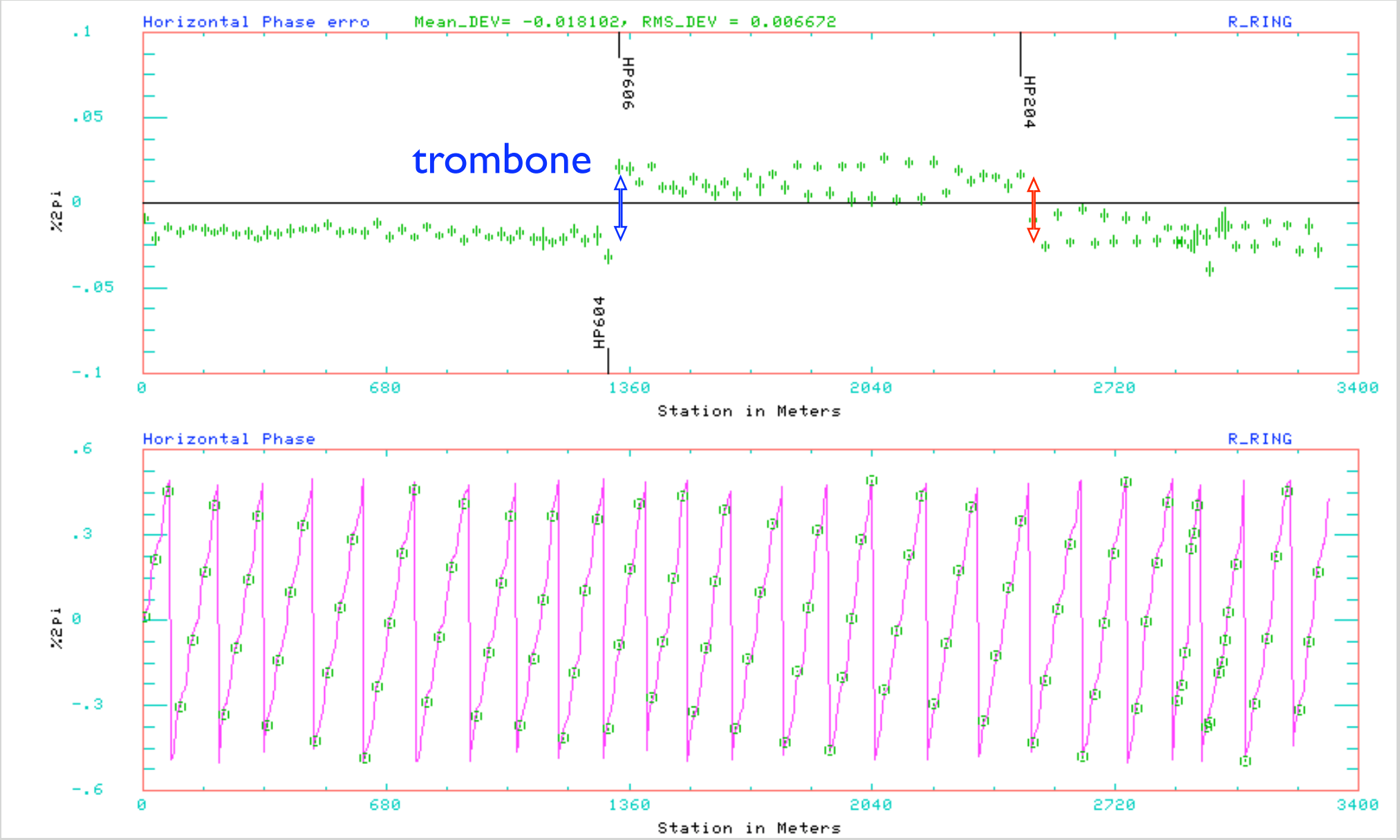
	Old	Delta	New	
R:H106	-0.139	0.012	-0.127	A
R:H302	1.124	0.019	1.143	A
R:H310	-1.360	-0.018	-1.379	A
R:H408	0.760	0.021	0.781	A
R:H638	0.341	0.011	0.351	A

<Return>

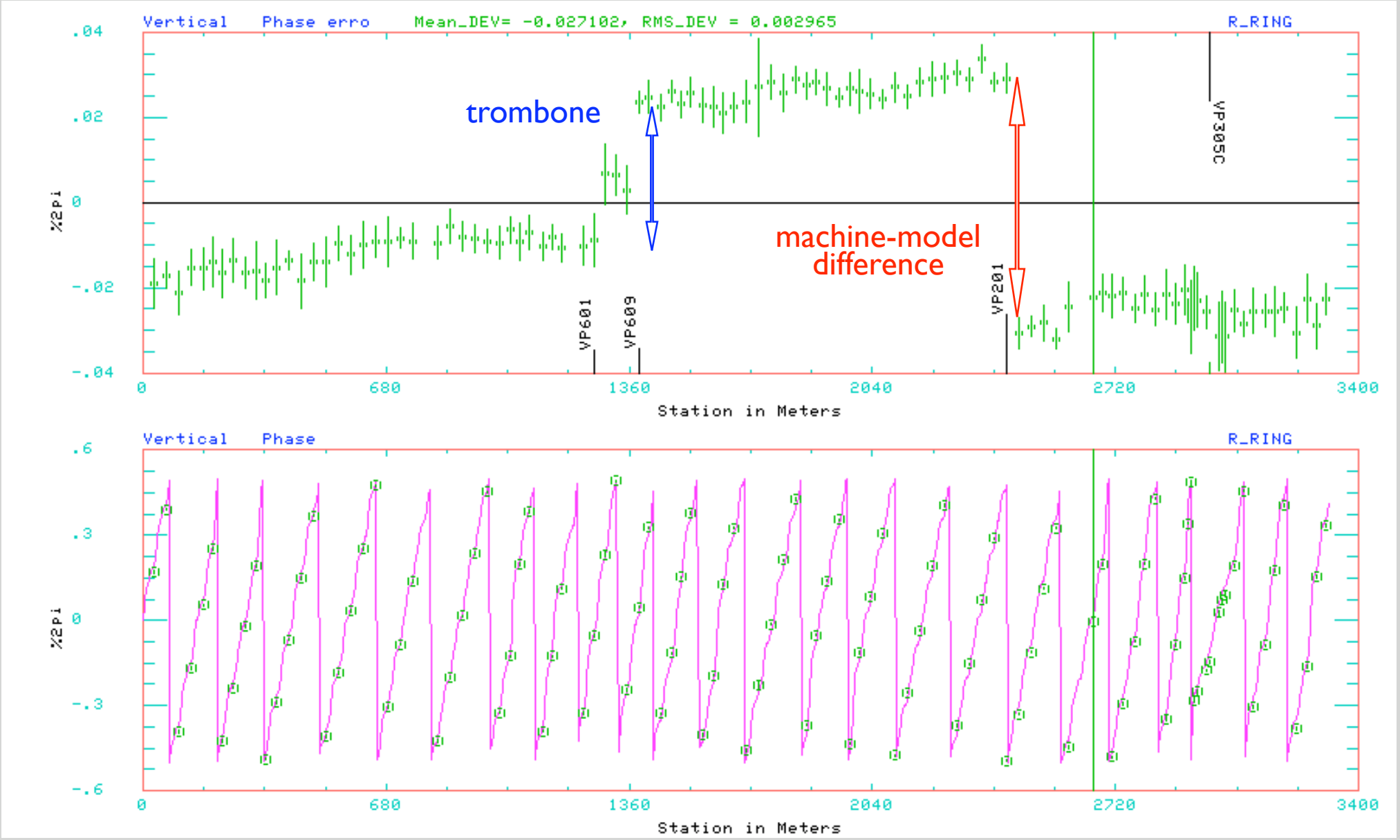
Tune with trombone ON



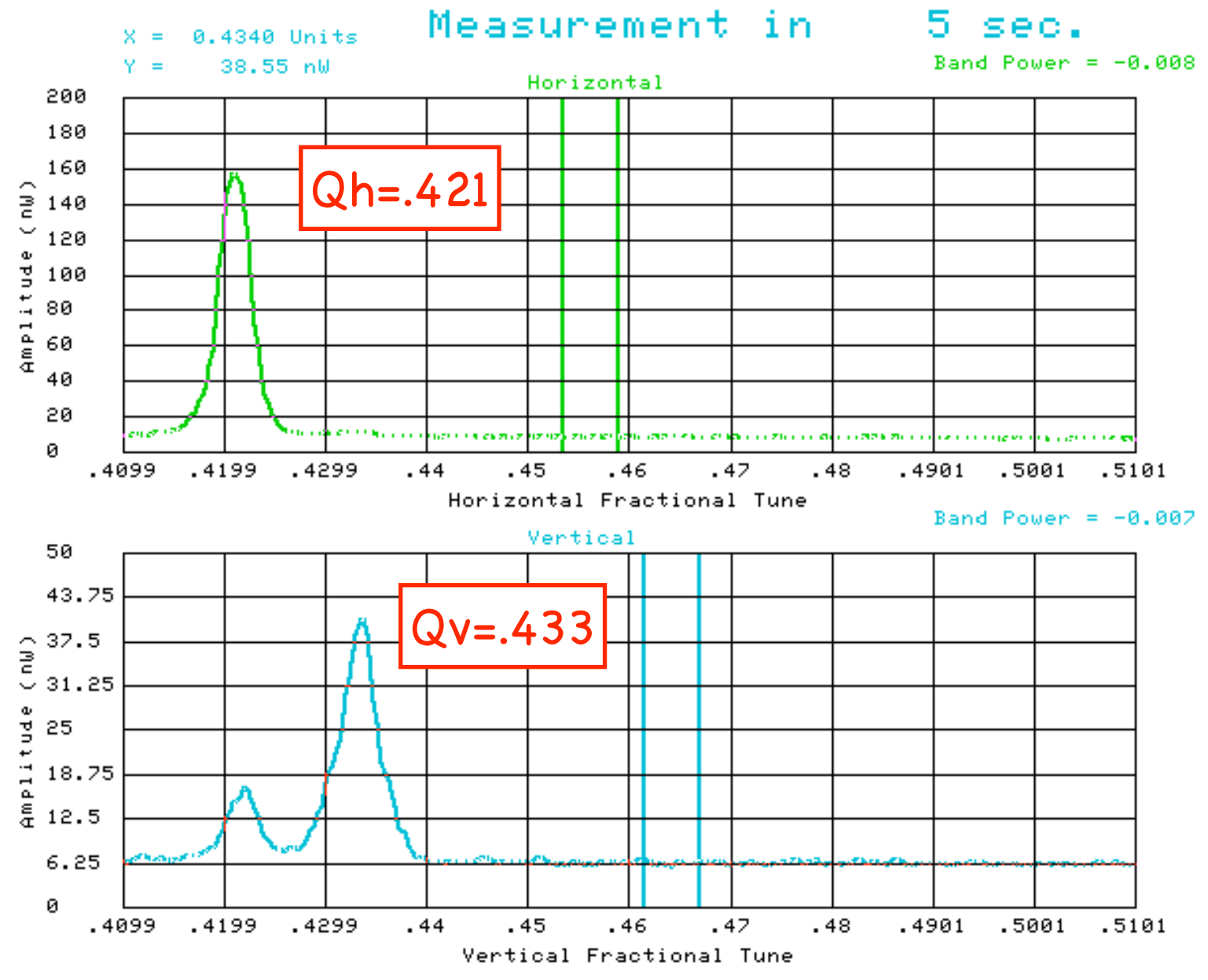
Horizontal phase advance, trombone ON



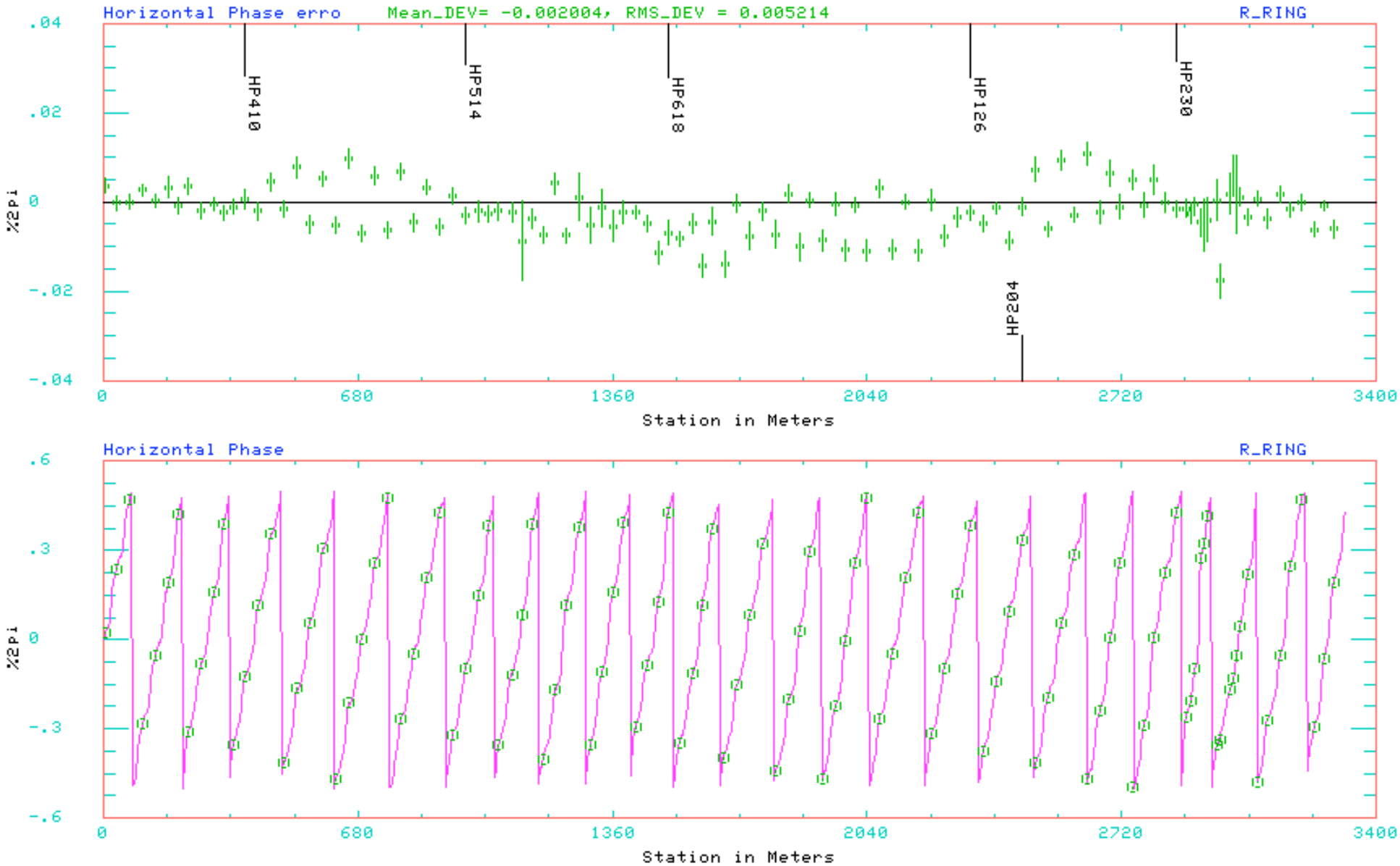
Vertical phase advance, trombone ON



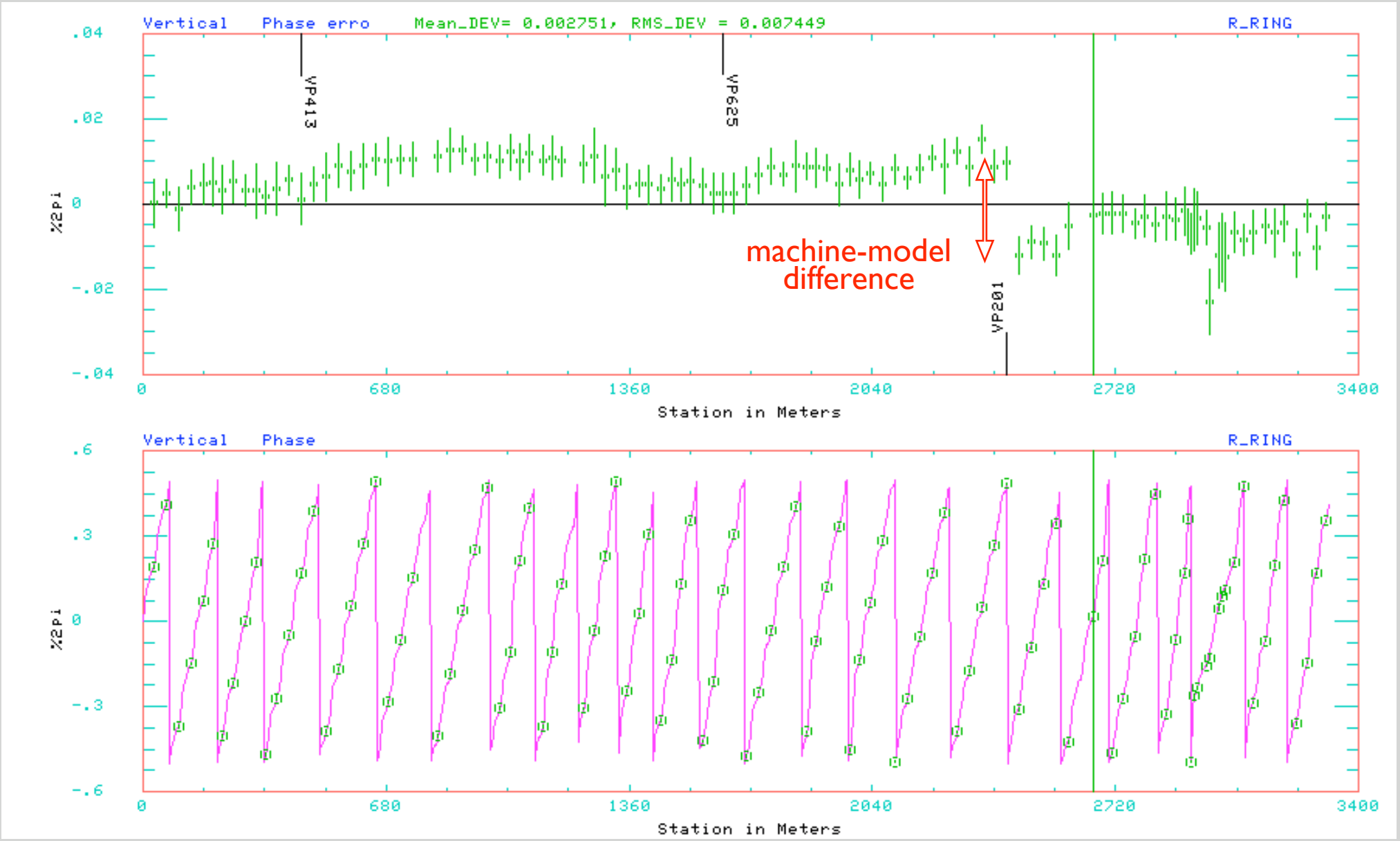
Tune with trombone OFF



Horizontal phase advance, trombone OFF



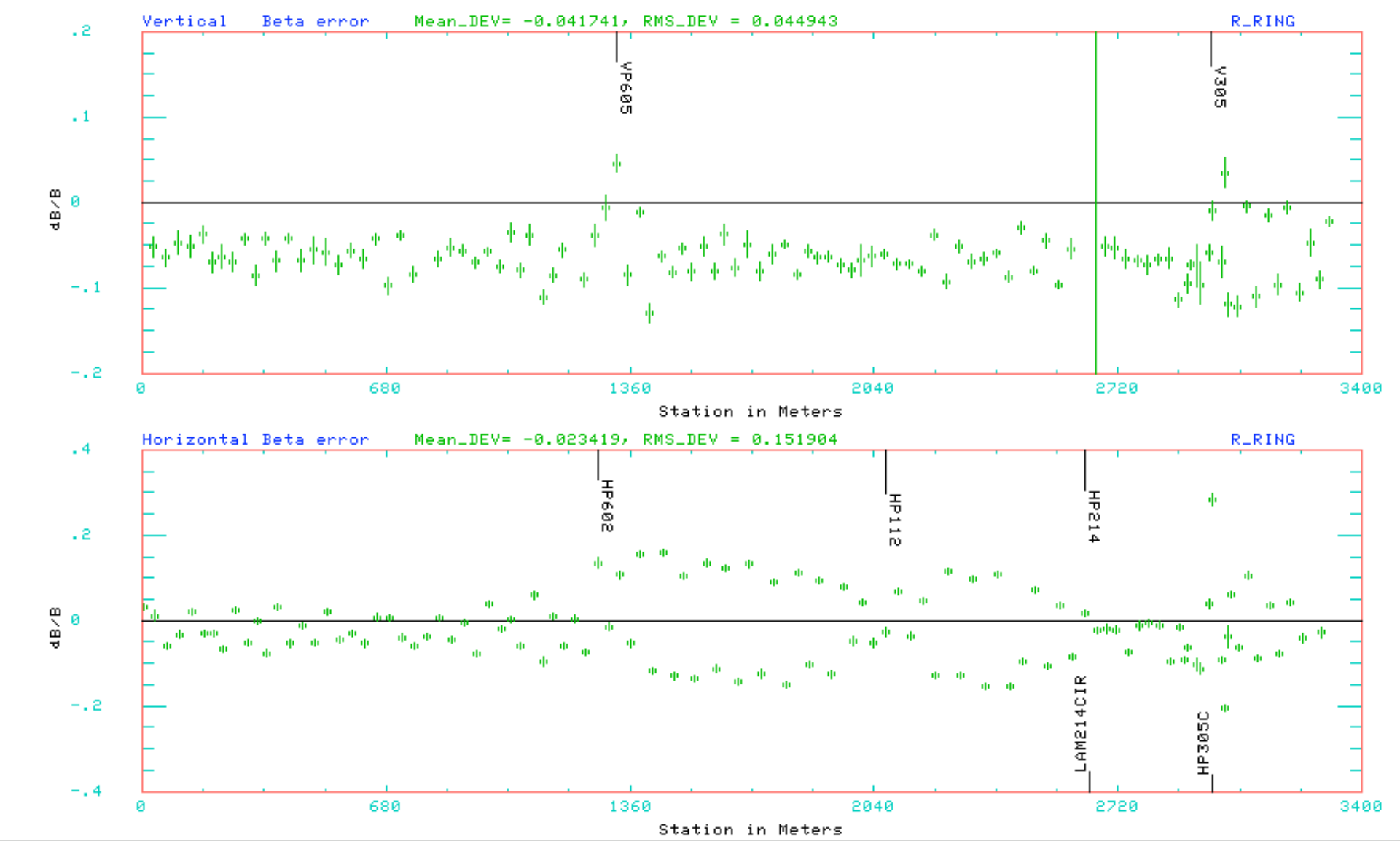
Vertical phase advance, trombone OFF



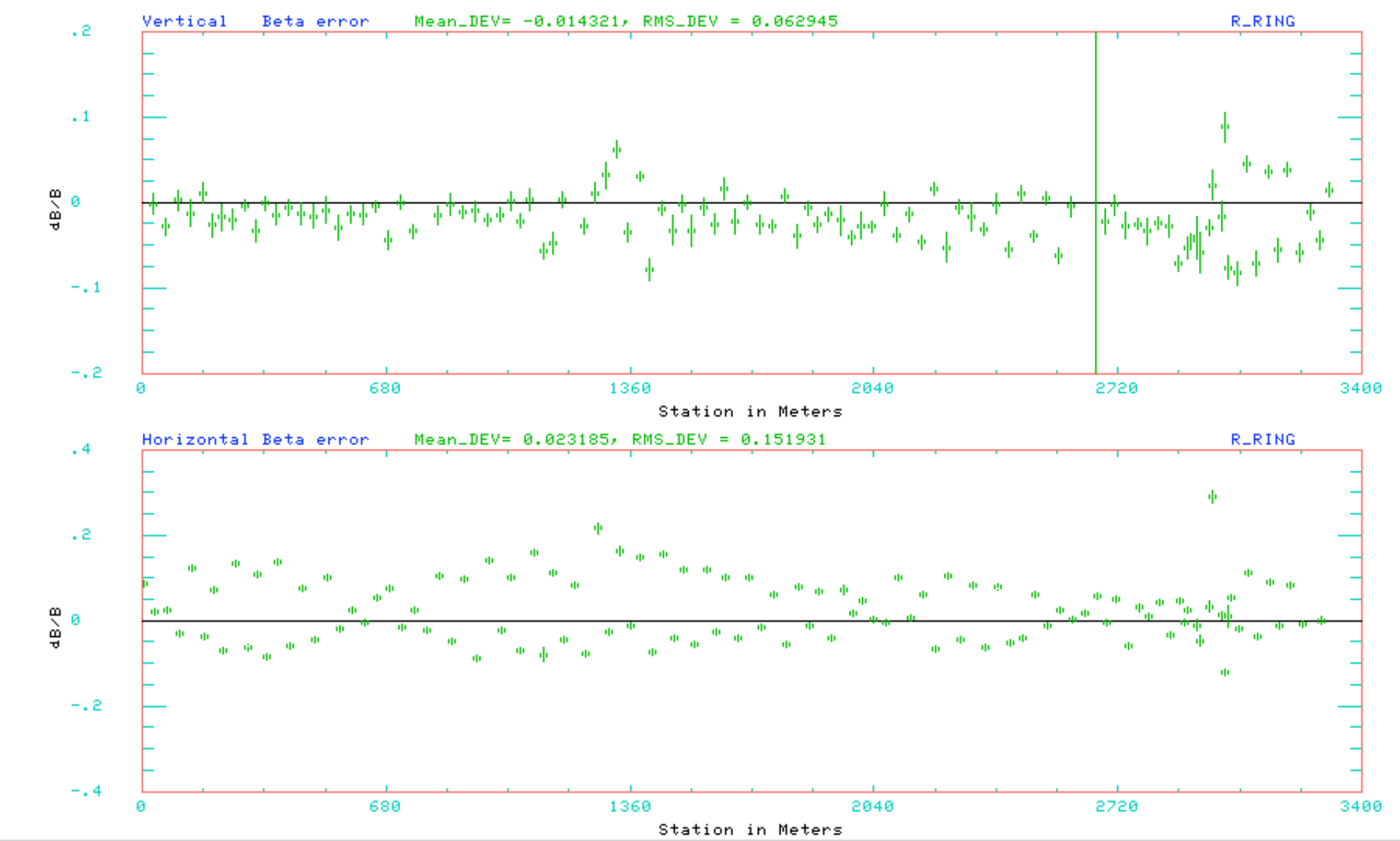
Phase advance

- Calculated tune from R90 program
  - Without trombone
    - horizontal 25.4275
    - vertical 24.4096
- Measurement from schottky
  - Trombone On (Off)
    - horizontal .455 (.421)
    - Vertical .469 (.433)
- Observed tune differentials
  - consistent with expectation
    - horizontal ~.3 (~-.005)
    - vertical ~.6 (~ .025)

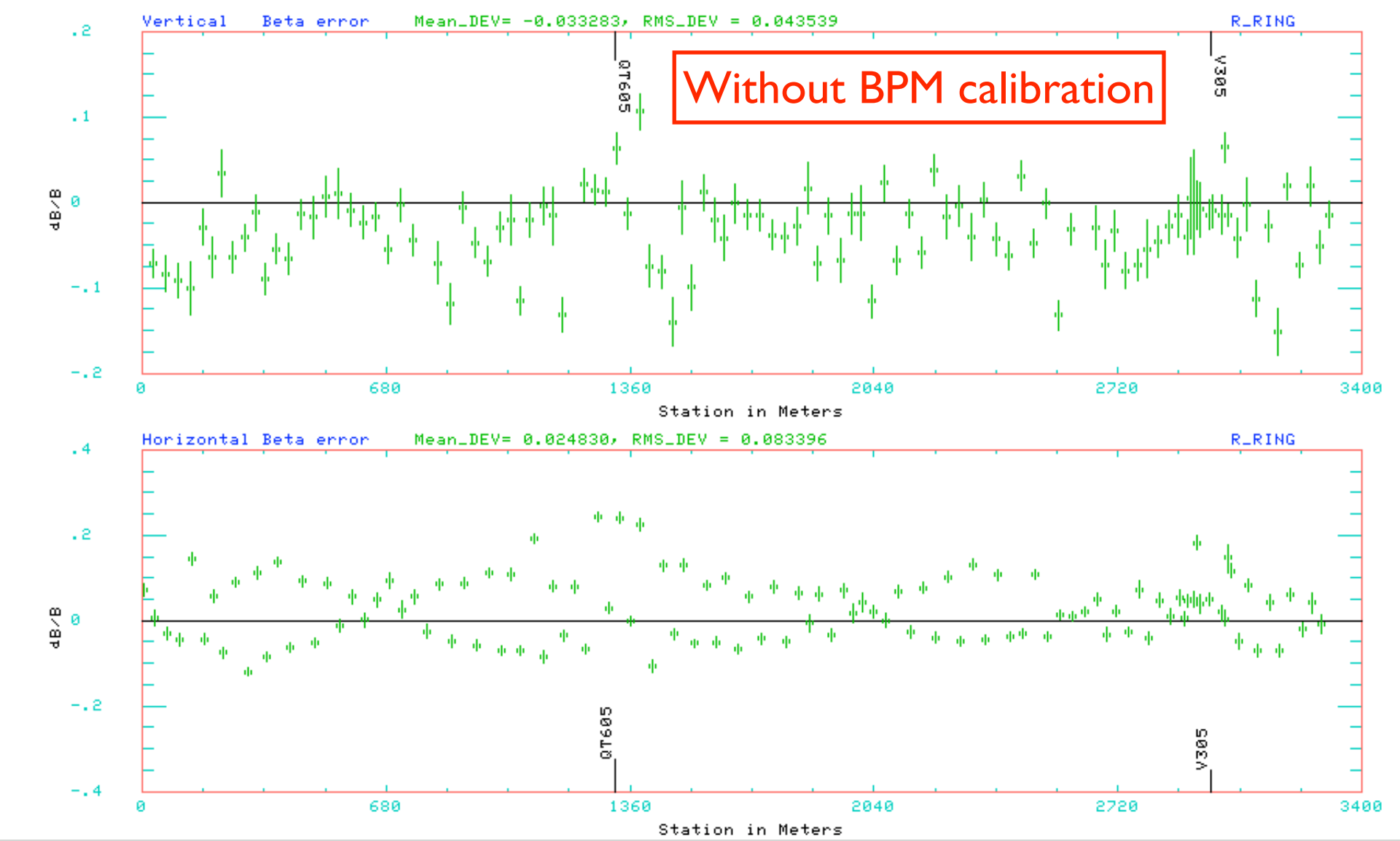
ΔBeta/beta, trombone ON



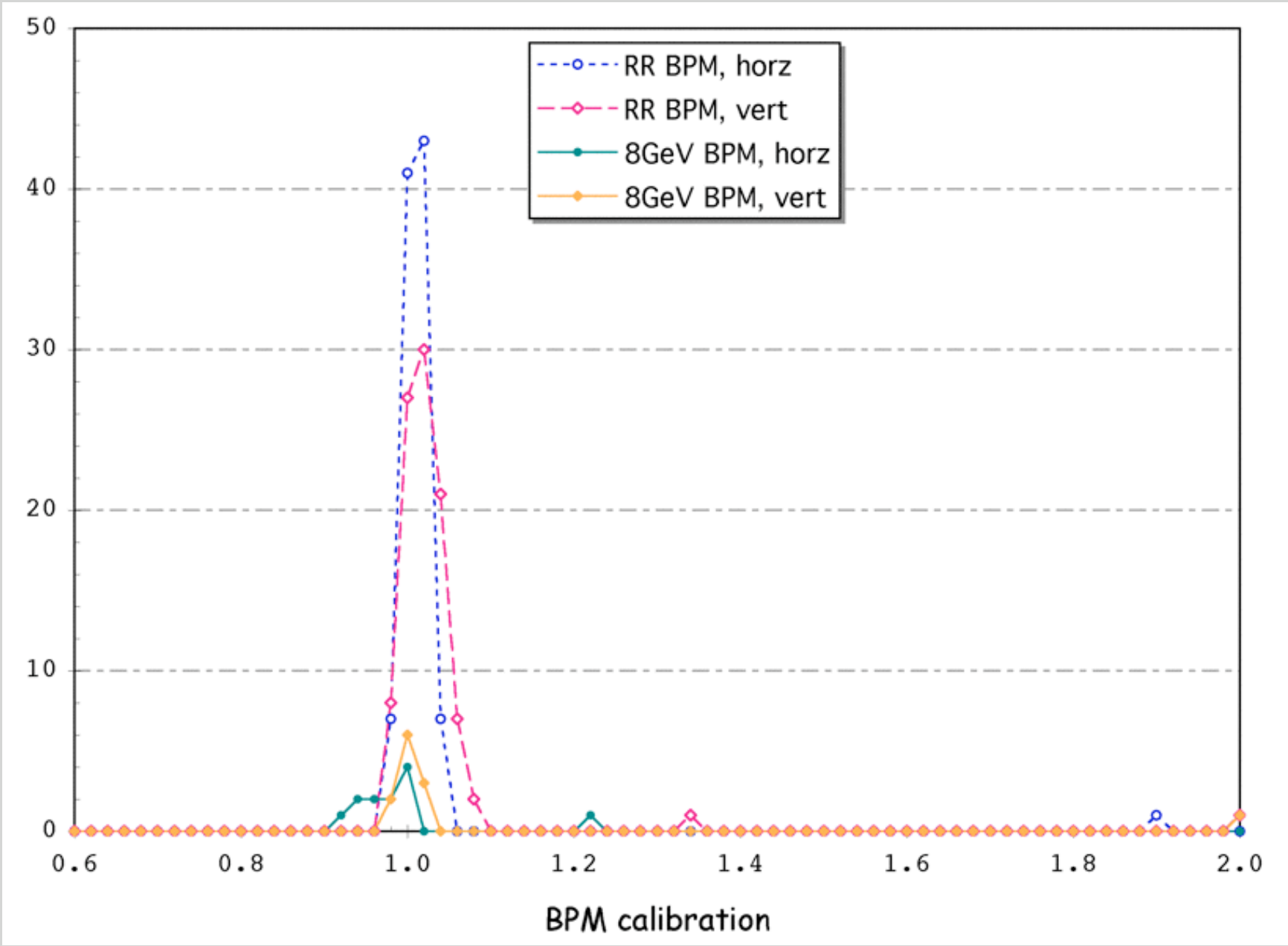
ΔBeta/beta, trombone OFF



ΔBeta/beta, trombone OFF



Relative RR BPM calibration, TBT analysis



Conclusion >>>

- Coupling
  - Horizontal to vertical: 10%.
  - Vertical to Horizontal: 5%.
  - Identified possible source locations.
    - Around 30 straight.
    - Between 630 and 100 locations.
- Beta function
  - Measurement
    - About 20% beta wave in horizontal plane.
    - Very minimal beta wave in vertical plane.
    - beta plot without trombone:
      - http://www-ap.fnal.gov/~yang/RR/CO070201/rr_beta.gif
    - Trombone does change beta-wave pattern.
  - Systematic errors
    - Overall BPM calibration.
    - Tune discrepancy.

<<< Conclusion

- Phase advance
  - Data
    - Key features in the data are understood.
  - Machine tune
    - Differed from that of calculation.
    - Both R90 and MAD have similar result.
    - Particularly in the vertical plane.
  - Possible sources of discrepancy
    - Feed-down from orbit offsets.
    - Beam off-center at trim sextupoles.
    - Beam energy calibration
      - being ~0.5% down from MI 8GeV level.
    - Or, all of the above.